THE CHEMCAM INSTRUMENT FOR THE 2011 MARS SCIENCE LABORATORY MISSION: SYSTEM REQUIREMENTS AND PERFORMANCE

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The ChemCam experiment is one of ten onboard the Mars Science Laboratory (MSL) rover "Curiosity", currently scheduled for launch in late 2011. The instrument is a combination of a Laser-Induced Breakdown Spectrometer (LIBS) and a Remote Micro-Imager (RMI) camera. The LIBS subsystem will provide remote sensing (up to ~7m range) data on the composition and elemental abundances of rocks and soils via active interrogation by a high-power laser. It is also possible to obtain passive spectra of targets using the LIBS subsystem and natural illumination. The RMI subsystem provides high-resolution images of the target regions interrogated by the LIBS laser, and will be used to provide geologic context for the LIBS data. This is the first use of a LIBS system in space.

ChemCam is physically divided into two separate units: the Mast Unit (MU) and the Body Unit (BU). The MU is located at the top of the rover mast, ~2 meters above ground level, and consists of an optical telescope, a Nd/KGW laser, the RMI camera and supporting electronics. The MU is provided by the French part of the ChemCam team, IRAP laboratory, supported by CNES, the French Space Agency. The Body Unit consists of an optical demultiplexer, three independent spectrometers with CCD detectors, the experiment controller, and supporting electronics, and is located inside the body of the rover. The BU is provided by Los Alamos National Laboratory. The MU and BU are interconnected via fiber optic and electrical cables, both contributed by Jet Propulsion Laboratory.

In order to excite small areas of geologic targets to temperatures high enough to radiate photons that can be analyzed by the LIBS subsystem, laser power densities of > 1 GW/cm^2 at the sample are needed and, for ChemCam, these densities need to be achieved over distances ranging from 1-7 m from the rover mast. Other laser requirements for successful LIBS analyses include laser spot diameters of 200 – 600 μm over the given range, pulse energy at the sample > 13 mJ, pulse durations of ~5 ns and beam quality of $M^2 < 3$.

The ChemCam 110 mm diameter telescope must perform three distinct functions: it must direct and focus the intense laser output (λ=1067 nm) on targets over the required range, it must efficiently collect the photons (λ range = 240–870 nm) emitted by the plasma cloud generated at the sample by the laser and transmit (efficiency 15-40%) this light to the remotely-located spectrometers, and it must act as specialized "telephoto" lens for the RMI subsystem. The RMI camera itself must provide < 100 μrad resolution to enable adequate imaging of the interrogated samples. The entire optical subsystem must be capable of auto-focusing very precisely over the required operational range.

The optical demultiplexer subsystem of the BU must efficiently divide the LIBS photons collected by the telescope into three optical bands (UV = 240-340 nm, VIS = 385-465 nm and VNIR = 475-870 nm) and feed these photons to the three spectrometers that are optimized for their respective wavebands. The spectrometers are required to achieve optical resolutions of 0.2, 0.2, and 0.65nm (FWHM) for UV, VIS and VNIR respectively and the wavelength drift with temperature should be < 0.1 pixel/C.

Extensive testing at the subsystem, integrated-instrument and integrated-system level show that all performance requirements are met over distance, temperature, etc. and that ChemCam is fully capable of achieving its science goals when it lands on the surface of Mars in August, 2012. This talk will detail the performance requirements that need to be met for successful ChemCam operation, the testing that has been performed to date to insure these requirements are being met and the overall instrument performance that can be expected on the surface of the Red Planet.